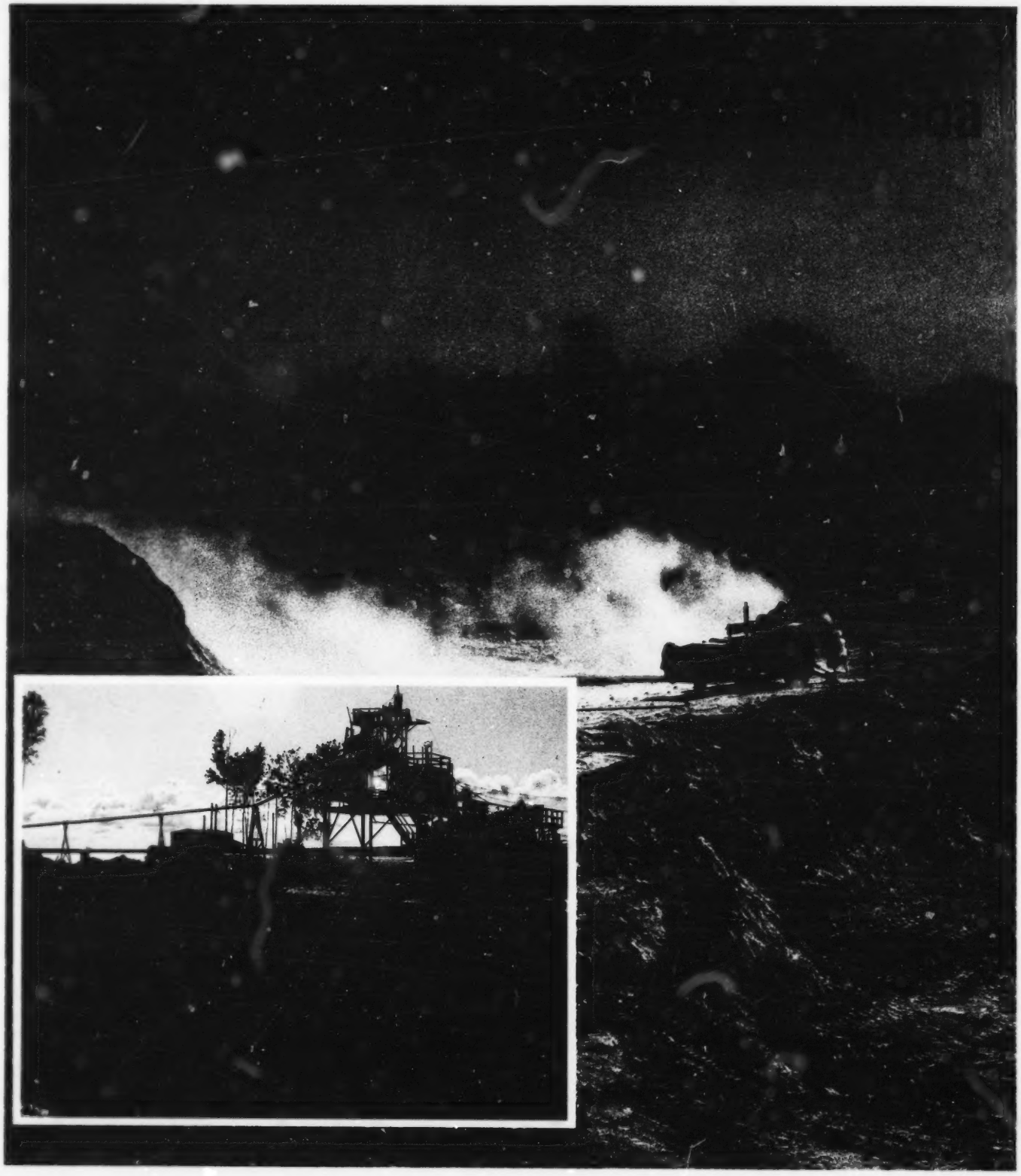
MINERALS

ECONOMIC & REGIONAL DEVELOPMENT AGREEMENT



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Industrial Minerals of Manitoba

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INTRODUCTION

This publication reviews industrial minerals within the Province of Manitoba, Canada. It is intended to alert mining development companies and resource processing industries, in Canada and abroad, to the opportunities offered by Manitoba's industrial mineral resources.

For the purpose of this review, industrial minerals are broadly defined as any mineable products which do not yield a metal as a final product. Information on Manitoba's copper, zinc, nickel, lead and gold industries is available in a number of Manitoba Energy and Mines publications. The mineral occurrences highlighted here have been documented in public and private records of present and former exploration and mining operations. This more detailed information is readily available from the Geological Services Branch of Manitoba Energy and Mines and should be read in conjunction with the Mineral Map of Manitoba (Map 80-1) which shows the known locations of mineral properties.

Potential investors and producers should note that the Government of Manitoba is developing innovative energy policies to encourage energy-intensive processing industries to take advantage of Manitoba's low electricity rates. Located at the geographic centre of the continent, Manitoba offers a strategic location in North American markets. Manitoba producers benefit from an excellent land transportation system leading to ports in Vancouver and the Great Lakes. Manitoba features two trans-continental rail lines, a number of regional trunk lines, and a good local road network.

For further information on the geology of Manitoba, industrial minerals and the level of geological investigation which has been carried out, contact Richard Gunter, (204) 945-6584. Questions relating to economic development and industrial mineral policy matters should be directed to Sylvain Segard, (204) 945-1876. For questions regarding aggregate reserves and production contact Bob Young at (204) 945-6507.

Information about development procedure and exploration and production permits can be obtained from the Mining Recording Office. Interested parties should contact Sheena Shetty, (204) 945-6526.

COMMODITIES

Industrial minerals available in Manitoba are presented below under three categories: minerals already in production which have additional development potential, minerals not in production that present good development potential based on current geological information, and minerals which are known to occur but require additional exploration work to determine their economic potential.

CURRENT INDUSTRIAL MINERAL PRODUCTION

The commodities outlined below are currently in commercial production. With additional geological and market research, they may present good market expansion potential. Company names are cited as examples only, and do not reflect endorsement by the Government of Manitoba.

AGATE

Agate is microcrystalline quartz which is used as a semi-precious stone. The agate beds in Manitoba are found in Tertiary gravels, which are believed to have been reworked in Pleistocene times. The best known deposit is near Souris, where the gravel is quarried for road aggregate. Other reported agate beds are found on the north slope of Turtle Mountain and the north and east slopes of Duck Mountain.

The Souris River agate deposits are located primarily in a ten-acre, privately owned open pit area operated by Souris River Gem Ltd. During the snow-free months, the deposits attract hundreds of visitors, including rock enthusiasts from Canada, the U.S. and other countries. Within the agate pit, rock enthusiasts may also find jasper, petrified wood, flint, opal, and epidote. Approximately four tonnes of these rocks are removed annually.

Souris River Gem Ltd. also cuts the agate into various ornamental shapes (as wind chimes, clock faces and other novelty items) for sale. In addition, the company imports rough agate from Brazil for finishing. More uniform and colourful than the Souris agate, the Brazilian agate commands a higher price. Rough agate sells for about $1.50/lb. to over $25.00/lb. depending on origin, colour and size.

The major international agate producers include Africa, Brazil, Uruguay and India. These countries ship rough and finished agate worldwide for use as costume jewellery. Taiwan is the major distribution and gem-cutting centre for agate and other gemstones. However, it is unlikely that any Canadian agate is exported for cutting. Instead, it is used by hobbyists for ornament and jewellery making. Souris agate sales are limited by a declining interest in the gem-cutting hobby.

AGGREGATES

Manitoba is endowed with abundant sand and gravel deposits throughout the province. Although the type, quality, and quantity of these aggregate resources vary according to locality, the supply is generally abundant. The importance of sand and gravel products in construction makes careful management of this non-renewable resource essential to ensure adequate supplies of quality aggregates for generations to come.

Sand and gravel production has averaged over 13 million tonnes annually, for an average value of $26.7 million per year, over the last 10 years. Road construction consumed more than 50% of this production. The remainder was used in concrete, fill, mine backfill, asphalt, railroad ballast, ice control and masonry products. Twenty large-scale commercial sand and gravel producers in the province employ an average of 225 people per year. An additional 250 smaller contractors supply aggregate resources for ready-mix concrete and various construction projects. An equal number of individuals or small contractors also operate sand and gravel pits on a casual basis.

Provided a permit is obtained from the Manitoba Mining Recording Office and that operators follow good management practices and land reclamation, provincial authorities will help investors locate suitable aggregate resources and obtain quarrying rights.

BENTONITE

Bentonite is an altered volcanic ash that has a high content of the clay mineral montmorillonite. Manitoba is a major North American producer of non-swelling and acid-activated bentonite, extracted from the Pembina Member of the Vermilion River Formation, near Morden, Manitoba.

Established in 1939, Pembina Mountain Clays Inc. presently employs seven workers at the quarrying, grinding and storage facilities at the deposit. An additional 22 employees work at the treatment plant in Winnipeg. The finished product is an activated calcium bentonite in dry powder form which is sold in bulk or bags primarily to vegetable oil refineries, especially in Alberta and Ontario. It is also used to refine waste mineral oil and tallow soaps. About 12 grades are sold by Pembina Mountain Clays and annual production is about 18,000 tonnes. The company supplies the Canadian market and the northern mid-west of the United States. Most of the U.S. market is supplied by the parent company, Harshaw-Filtrol, which is owned by Kaiser Aluminum and Chemical Corporation.

A second occurrence of bentonite has been found in drill samples from the Coulter Member, underlying Boissevain sandstone near Turtle Mountain.

This occurrence contains a swelling variety of bentonite which is used primarily as an oil well drilling mud and as reservoir sealant. Although not presently mined, it is possibly the stratigraphic equivalent of the swelling bentonite produced commercially at Truax, Saskatchewan. Commercial production requires the location of near surface occurrences or outcrops of the bentonite. Additional exploration of the Coulter Member is required.

CEMENT

Two major portland cement plants near Winnipeg — Canada Cement Lafarge Ltd. and Genstar Cement Ltd. — constitute the industry in Manitoba. The Canada Cement plant is temporarily idle because of sluggish demand and high fuel costs. Both plants draw limestone from the Steep Rock quarry, on the northeast shore of Lake Manitoba, and clay from the Lake Agassiz varved clay beds adjacent to each of the plants.

Two other commodities are related to the production of portland cement: natural cement and expanded aggregate. Natural cement was produced in Manitoba before the introduction of portland cement in 1913. Production involved the burning of suitable clay-rich limestone of the Boyne Member near Deerwood in southwestern Manitoba. However the natural material was too variable to compete with portland cement and production ceased in 1924.

Expanded aggregate production involves heating clay or shale of suitable composition. The heat partly melts the clay into a pasty mass and escaping volatiles froth it into a lightweight, strong, porous solid. Lake Agassiz clays are particularly suitable for this type of aggregate. The resulting product is among the lightest and strongest found by Energy, Mines and Resources Canada in its extensive program of tests for bloating clays or shales.

Three small plants in Winnipeg have produced lightweight aggregate, although only Kildonan Concrete Ltd. is presently operating. Immediate demand for concrete block and redi-mix concrete currently limits the volume of production. However, this commodity may take on a higher priority in future. The material could be produced in larger quantities and shipped to out-of-province processors if economics warrant it.

BRICK CLAYS

Brick clays are mechanical mixtures of kaolinite, illite, quartz, carbonate, iron oxide and chlorite which will form a hard, non-porous, non-glossy body upon heating to fusion. Two types of bricks, common and face bricks, are generally produced. Of lesser quality, common bricks are used for the interior of walls and the sides and backs of buildings. Face bricks have a more attractive colour and are used as the outside cladding for walls commonly seen by the public. In total, more than forty common brick plants operated in Manitoba at various times. These plants gradually closed as the market for common brick diminished.

Red River Brick and Tile Co., owned by I-XL Industries Ltd. of Medicine Hat, Alberta, operates the only brick plant in Manitoba today. Located in Lockport, plant capacity is 15 million bricks per year. The plant has

been operating at just over 50% of capacity, providing work for 30 employees for nine months of the year. Red River Brick produces about 12 shades of building brick in three sizes. It also manufactures two sizes of paving brick. The list price of their most popular brick is $306.00 per 1000 brick ex plant. Red River Brick sells most of its product in Manitoba although Alberta constitutes a significant market, followed by Ontario and Saskatchewan. Although I-XL Industries Ltd. has three brick plants in Alberta, the company imports large quantities of Manitoba bricks because of their unique purple-brown colour.

GYPSUM

Gypsum is a major industrial mineral used in the fabrication of wallboard and cement. Gypsum production in Manitoba dates back to 1901. Today, two producing areas, the Harcus quarry near Amaranth and the Gypsumville quarry north of Lake St. Martin, provide the feedstock for two wallboard plants and two cement plants in Winnipeg. The quarries also export gypsum to Saskatchewan wallboard and cement producers.

Found in the Jurassic Amaranth Formation, all deposits have substantial reserves and can support expanded production. Gypsum is a relatively low unit-price commodity. Transportation and mining costs are important factors in determining the viability of the two gypsum operators — Westroc Industries and Domtar Inc. Although gypsum was once mined underground at Amaranth and Silver Plains, it is presently produced from quarries at Harcus and Gypsumville. Research into fine grinding processes funded under the Gypsum Comminution Project, a joint Federal-Provincial program, will help reduce the cost of producing gypsum wallboards. With increasing efficiency, Manitoba's gypsum industry has excellent potential to expand on its established market.

DIMENSION STONE

Dimension stone is the name given to natural rock that has been quarried and shaped to certain dimensions for use in the building, construction and monument industries. The term includes rough stone, blocks, panels and polished material, but does not cover crushed or powdered stone used as an aggregate or reconstituted to form artificial stone. Dimension stone is commercially classified as:

Granite:	crystalline igneous/metamorphic rock
Sandstone:	granular sedimentary rock
Limestone:	non-polished carbonate rock
Marble:	carbonate-bearing polishable rock

Total world production of dimension stone is about 15 million tonnes per year, with Italy accounting for one third. Quebec is by far the dominant producer of dimension stone in Canada, followed by Ontario. Manitoba is a distant third, shipping 11,000 tonnes, valued at $1 million, in 1982.

Four companies quarry dimension stone in Manitoba. Gillis Quarries Ltd. produces a dolomitic limestone known as "Tyndall Stone". The mottled colour of Tyndall stone can be seen in many buildings across Canada. Whiteshell Quarries Ltd. markets a micaceous schist called "Flame Rock" as well as some limestone, sandstone and granite. Flame Rock has been used as a fireplace finishing surface in many Winnipeg houses. Cold Spring Granite (Canada) Ltd. and Shield Quarries of Canada Ltd. both produce granite which is used mainly for monuments. Several small quarries, opened along the Thompson-The Pas railroad, produced a pink-red patchy ornamental dolomite used for doorposts, lintels, and other similar products. However, the "Manitoba Marble" quarries are now closed.

Most Manitoba dimension stone production is generally shipped to markets as rough blocks. Dimension stone cutting is performed by Tyndall stone producers but there are no full-scale finishing plants in the province. On the other hand, for a different stone product, blocks of rough granite are imported from Quebec to be cut and polished in an automated tile finishing plant. This operator, Canital Granites Ltd., produces ornamental tiling at competitive price. If suitable granites were found within the province, granite floor and wall tile markets could be expanded to the greater part of western Canada and United States.

The market for dimension stone and other building stone products has been strengthening. With several potential granite quarries located close to transportation routes in southeastern Manitoba, opportunities exist for further expansion and development of the dimension stone industry.

A long-standing exploration program exists in Manitoba, and Energy and Mines maintains extensive files on promising sites. The building stone industry is given a high priority for further study and project development. Samples of honed, polished and fired building stone available from various potential new quarries can be obtained from Energy and Mines by interested investors, stone product wholesalers, and architects.

DOLOMITE

Dolomite is a normal constituent of all carbonate rocks. Limestones are a mixture of calcite and dolomite, with most not approaching either mineral's pure composition. In Manitoba, dolomite is used mainly as crushed stone and roadfill, as building stone and ornamental stone, or as pulverized stone for high-magnesium lime.

The dolomite used for high-magnesium lime is quarried at Hilbre. It was formerly produced at numerous other localities, notably Stonewall and Inwood.

A number of operators quarry dolomite for crushed stone and roadfill at Stonewall, Stony Mountain and elsewhere throughout the province. Transportation costs of crushed dolomite generally outweigh all other considerations, since the specifications for chemical and physical properties are not very strict for this type

of use. Thus, quarry location is a major determinant of commodity prices. The identification of good quarry sites is an important cost factor for many public projects.

The dolomite used for building stone comes from the Tyndall stone quarries at Garson, northeast of Winnipeg. These quarries have been exploited for many years and such edifices as the Parliament Buildings in Ottawa and the Legislative Building in Winnipeg contain substantial quantities of this stone.

Several quarries on the Hudson Bay Railroad, northeast of The Pas have, in the past, produced dolomite for ornamental stone. The University of Manitoba has several examples of this "Manitoba Marble" as doorposts, columns and other decorative stonework.

The crushed stone and Tyndall stone uses of dolomite have a low priority for further geological study. Extensive literature exists for both and both have adequate reserves identified for the foreseeable future. The ornamental stone warrants closer attention. Little information is available on the former quarries regarding their size, constancy, rock impurities and other factors which caused the closure of this segment of the dimension stone industry. It may be significant that most ceased operation during the depression of the 1930s.

LIMESTONE

Manitoba contains several areas of limestone with sufficient purity to be used in cement-making. A major study of the high-calcium limestones of Manitoba by the Department of Energy and Mines, completed in 1975, outlines present and past producers in detail and provides comprehensive information on the locations of high-calcium limestone. Considerable reserves at the Manitoba cement manufacturers' quarry at Steep Rock are available to respond to expected regional market demands for cement.

In the long term, acidic pollutant legislation and management practices may have a significant positive influence on lime production as it is one of the major acid neutralizing agents.

PEAT

Peat is an organic material resulting from the slow decomposition of vegetation in acidic environments. Because of the nature of peat harvesting operations, peat production is regulated as an industrial mineral.

Two large peat operations in Manitoba export over 90% of their peat moss production as baled peat or peat-fertilizer mixtures to the United States. The rest is distributed to nurseries and horticulturists in Manitoba, Saskatchewan and Alberta. Fisons Western Corporation and Premier West Peat Moss Ltd. employ about 225 people on a seasonal basis. The value of their production averages about $10 million per year.

Important peat reserves are available in Manitoba. More than 35 sphagnum bogs have been inventoried and their peat production potential assessed. Upon further study, development and expansion opportunities may be uncovered.

RARE ELEMENTS

Several rare elements have been reported in the granitic pegmatites of Manitoba. These include beryllium, cesium, gallium, lithium, molybdenum, rubidium, tantalum and tin. Rose quartz, topaz and tourmaline also occur as minerals in the pegmatites. The pegmatites range in size from small pods or lenses to the giant zoned Tanco mine at Bernic Lake — one of the world's largest rare-element-bearing pegmatites. Most of the known deposits occur in southeastern Manitoba, in three distinct fields.

Small amounts of all these rare elements were produced in the past. However, most production is from the Bernic Lake pegmatites. Operated by different companies since it was first exploited, the Bernic Lake deposit has produced important amounts of cesium and lithium and lesser amounts of rubidium, gallium and beryllium. However, the significance of this mine lies in its large tantalite reserves, one of only a few in the world.

The Tantalum Mining Corporation of Canada Ltd. (Tanco) employs an average of thirty employees in the production of lithium and rubidium. Following a period of volatile prices and constrained world demand for tantalum, Tanco has sold tantalum only from its stockpiles in recent years. However, tantalite mining is expected to resume shortly as stabilized prices may warrant new production. Tanco is also considering the feasibility of diversifying its production by adding potassium and sodium feldspar to the six products it already produces.

The volume of ore concentrate produced from the Bernic lake depcsits is modest; approximately 100 tons of tantalite, 600 tons of pollucite (cesium ore), and 15,000 tons of spodumene (lithium ore) every year. However, their high market prices make production attractive. Production is currently valued at about $1.5 million annually. With the possible reopening of tantalum production, total output from Tanco is estimated at about $8.0 million per year. Depending on the outcome of the ongoing feldspar studies, production values may increase further in the near future.

SILICA SAND

Silica is one of the most widely used industrial minerals. Its principal uses are in glass-making, silicon metal, ferro-silicon used in steel-making, silicon carbide for grit, refractory silica brick, siliceous flux used for smelting, and sandblasting. All of these uses have specifications requiring low levels of impurties — less than 1% iron and aluminum can generally be tolerated.

In Manitoba, a large quantity of pure silica sand is extracted at Black Island by Marine Transport Ltd. The washed quartz sand is consumed by various Manitoba industries or exported to Alberta and Saskatchewan.

PROMISING INDUSTRIAL MINERALS

The commodities described below present the best development opportunities. Additional geological work is required to confirm the extent of reserves but these minerals are generally perceived as having the best potential for future development, either because they are available in significant quantities and grades, or because their occurrence is of interest relative to current world production.

COMMON AND POTTER'S CLAYS

Clays are a series of minerals composed mainly of silica, alumina and water. They should have the desirable property of forming a hard glossy surface upon heating. Common clays include potter's clay and brick clays, whereas specialty clays such as bentonite and kaolin have more specialized applications. Common clays are characterized by high bulk, low unit value, and sensitivity to transport cost. Common clays are found in all parts of Canada, but deposits with excellent drying and firing properties are rare in Manitoba.

Common clay in Manitoba has a specific use at the copper-zinc smelter in Thompson. Local clay called "swamp clay" is used as a lining for certain portions of the furnace used in the smelting process, where rigid thermal behaviour is not required. At present, an abundant supply of this type of clay is available from the local Lake Agassiz clays.

CHROMITE

Chromite is a commodity of strategic importance because its world supply, though abundant, is concentrated in politically unstable countries and the U.S.S.R. Since there are no chromite mining operations in North America, it is crucial to ensure a reliable supply of chromium for use in the fabrication of stainless steel, refractories, various chemicals and pigments.

Of all the chromite occurrences known in North America, the deposits which are receiving the most attention in terms of strategic and commercial evaluation are located in the Bird River Sill in southeast Manitoba.

The Bird River Sill chromite contains a high concentration of iron which, through new processing technology, makes it of economic interest in the production of stainless steel. The deposit consists of several stratiform seams of massive and disseminated chromite located in ultramafic rock.

The Sill has been the subject of intensive investigation by Energy and Mines in past years. Evidence has prompted a comprehensive evaluation of the chromite deposit under the Canada-Manitoba Mineral Development Agreement. The objective of these studies is to determine whether the low grade chromite ore can be processed in a fully integrated facility to produce stainless steel slabs on a competitive basis.

Minor occurrences of chromite reported at Embury Lake and in the Fox River Sill are also the subject of studies by the Geological Survey of Canada.

GARNET

Garnet is a common metamorphic mineral whose use as an abrasive takes advantage of the mineral's hardness and lack of cleavage.

Manitoba's garnet deposits are found in rocks that have undergone regional metamorphism. The size and form of crystals found to date are of sufficiently good quality to be considered as mineral specimens. For example, good specimens have been removed from File Lake. Garnets more commonly occur as multi-crystalline "snowballs". These aggregates have no external faces and are often extensively fractured.

This garnet, if pure enough, is the type used for abrasives. The fractures allow the garnet to be crushed to produce sharp edges that act as cutting surfaces. Under certain metamorphic and chemical conditions, a rock of almost pure garnet can be formed, which would be the ideal raw material for the abrasive product.

Several localities were examined and sampled in the summer of 1984. The most promising occurrences were mapped in detail in 1985 and 1986. Further study is required, but the use of Manitoba snowball garnet, for abrasives, is of interest.

GLAUCONITE

Glauconite is an authigenic mineral in sedimentary environments containing both mobile iron and mobile potassium. A lagoon bottom with a low pH and low dissolved oxygen may be typical of such an environment.

In Manitoba, glauconite recently was discovered in large quantities within the Swan River Formation. The deposit is near Steeprock River, northwest of the town of Mafeking. An interim report on the chemistry and mineralogy of this deposit has been prepared.

The chemistry and mineralogy of glauconite are fairly well known. However, the field relations and the mineral variations within the glauconitic beds are not well known, since there is little outcrop in the Mafeking area.

The demand for glauconite is limited to its use in water treatment and soil conditioning. Also known as green sand and commercially as zeolite, glauconite production is valued at about $50-55 per tonne for agricultural grade and $120-270 per tonne for water treatment grades. This deposit may become of interest in the near future as pressures to strengthen water quality standards increase.

HELIUM

Although there is no current production for commercial purposes, helium is found in Manitoba as a by-product of natural gas and oil production. Helium is used as a refrigerant or coolant for producing liquid nitrogen and as a stable gas for work such as welding where a noble gas is needed.

Several gas wells in Manitoba have helium in the 1-5% range reflecting an enriched helium content. However, an analysis of several samples of gas from springs in the Swan River area showed an average content of 0.4%. Unless there is a major change in the current supply situation for helium, further investigation of the Manitoba occurrences is not felt to be warranted.

KAOLINITE

Kaolinite is a white specialty clay which is formed from weathered igneous rock. It is used as raw material in whiteware ceramics, coating material in the paper industry, and filler for plastics, rubber and paper. Kaolinite is also a potential input for aluminum production.

Deposits in Manitoba are confined to the Swan River Formation and to weathered surfaces on Precambrian rocks in the Reed Lake area, Black Island and Deer Island. The only location currently exploited is the Red River Brick and Tile Co. pit south of the Ste. Rose du Lac where kaolinitic shales are being quarried for use in brick-making.

Other locations which have been tested for kaolinite indicate a problem of quartz contamination. The fine grained quartz produces a washed kaolinite product too gritty to be used as a coating or filler in paper. In the Swan River deposits, minor amounts of lignite and pyrite make the production of whiteware clay for ceramic use very expensive.

MINERAL COLLECTING

For amateur mineral collectors in Manitoba, two publications produced by Manitoba Energy and Mines outline mineral collecting localities; "Rocks, Mineral and Fossil Information and Services", and the two-volume set entitled "Minerals in Manitoba". There is also partial coverage of the province in the Geological Survey of Canada Paper 71-27 by A. Sabina.

A short list of localities that could be added to those contained in these publication includes the following:

amazonite	Sherridon
arsenopyrite	Rod Mine, Snow Lake
axinite	Nor-Acme Mine, Snow Lake
beryl	North Dyke, Cross Lake, Shatford Lake
brugnatellite	Pipe Lake Mine, Thompson
columbite	South Dyke, Cross Lake
cordierite	Nelson House
fuchsite	Winnipeg River
kyanite	Anderson Mine, Snow Lake
garnet	File Lake
garnet	Ram Zone, Snow Lake
rose quartz	Osis Lake
spessartine	South Dyke, Cross Lake
spodumene	South Dyke, Cross Lake
tourmaline	Bernic Lake, Cross Lake
uvarovite	Found Lake, Sherridon

POTASH

Sylvite is the major potassium component of agricultural fertilizers. A major potash deposit occurs in southwest Manitoba. This deposit is an extension of the potash-rich members of the Prairie Evaporite which have been mined for the past 30 years in Saskatchewan. Several properties were investigated in recent years by International Minerals and Chemicals Corporation, Amax of Canada Ltd., and Canamax Resources Ltd.

Extensive geological work on this deposit has confirmed the availability of large reserves of various grades. The sylvite members located in the vicinity of Russell have shown high potash contents. This stimulated a joint venture between Canamax Resources Ltd. and the Manitoba Government. To date, detailed engineering and economic studies indicate that mine production could be feasible, commencing in 1990. Subject to the result of transportation studies and marketing efforts, a development decision should be reached by the end of 1987. The Manitoba Potash Project, a world-class mine development, would support low-cost production of 2 million tonnes of potash annually for more than 30 years.

Improving market conditions in the 1990s, combined with low production costs, make the potash project an attractive investment. As a result, Canamax and Manitoba Government are approaching potential equity partners and attracting clients in anticipation of capital investment decisions.

SALT

Sodium is a commonly used industrial mineral. The former saltworks of the Canadian Salt Company in Neepawa, Manitoba, utilized the brine from two wells drilled between 1910 and 1935. By 1940, the tonnage from the wells reached 3,071 tonnes per year. The plant closed in 1970 due to cheaper salt obtained as a by-product from the solution mining of potash at Belle Plaine, Saskatchewan.

Dryden Chemicals Ltd., and later Hooker Chemicals Canada Ltd., produced brine for industrial use (sodium carbonate and soda ash) at their plant east of Brandon. The brine was in production from the early 1970s to the early 1980s. Production of the brine was halted for environmental reasons, and because of competition from the Saskatchewan salt.

TALC AND SOAPSTONE

Talc is valuable due to its whiteness, smoothness, high fusion point, low thermal and electrical conductivity, and chemical inertness. Soapstone is an impure compact form of talc. Talc is primarily used in a fine

ground state. It has many industrial applications. These include use in pulp and paper manufacture as a filler and coating pigment, use as an extender pigment in paints, and use in the ceramic, plastics and pharmaceutical industries.

Metamorphosed ultramafic bodies are the best locations in which to find talc deposits. However, studies have shown no large talc bodies in the ultramafic rocks of the Nickel Belt, Fox River Sill, Rice Lake or Bird River belts of Manitoba. Asbestos-bearing ultramafic rocks such as the Pipe Lake Mine cannot be used as a source of talc for health and safety reasons.

The most promising locations for talc deposits in Manitoba are on islands in Iskwasum Lake, and along the Grass River in Grass River Provincial Park, north of Provincial Road 391. A report by Manitoba Energy and Mines showed eleven areas with common-to-abundant talc in hand specimens, but a brief survey done in 1970/71 showed the talc was mixed with dolomite and, therefore, not viable. Improved beneficiation techniques pioneered by Baker Talc, with a similar deposit in the Eastern Townships, Quebec, suggest that a re-examination of this location may prove valuable.

Another noteworthy use of soapstone is by the arts community. Native Canadian soapstone carvings are known for their beauty and can reach significant market values. Although only minor quantities of soapstone blocks are quarried, sculptors require high quality pieces which are devoid of cracks or impurities.

OTHER INDUSTRIAL MINERAL OCCURRENCES

The commodities described below are of interest since comparatively little is known about current reserves. Further exploration work is required to determine their economic development potential.

ALUMINA

In Manitoba, all sources of high-alumina material are found in the form of kaolinite. Aluminum hydroxide, in the form of bauxite, is a major input in the production of aluminum, but is not known to occur in Manitoba. In 1980, when Alcan investigated the possibility of establishing an aluminum smelter in the province, the company was planning to import bauxite from offshore suppliers.

Alumina is also used in the fabrication of refractories. When of high purity, it is applied to chemical processes requiring catalytic or binder support. It is a component of high-quality abrasives. Several studies have been carried out by CANMET, the U.S. Bureau of Mines, and Norwegian interests to develop feasible alumina recovery processes from anorthosite and kaolinitic clays. Anorthosites are found at Cross and Pipestone Lakes.

AMBER

Amber is a fossil resin, normally associated with lignite beds. When amber is transparent it can be cut to make a very expensive gem. The major world supplier of gem quality amber is the Dominican Republic. An 18 inch strand of Dominican Republic amber, cut and polished, sells for about $75.00. High quality Baltic Sea amber in a 24 inch strand, cut and polished, may be purchased for about $300.00. Cedar Lake's islands and shore were the source for Manitoba's amber before the Grand Rapids dam was built in the mid-1960s. The locations are now flooded. Samples of the Cedar Lake material yielded small discoloured fragments that did not show good gem potential. Besides Cedar Lake, amber occurs in southeastern Alberta and Nova Scotia.

ASBESTOS

Asbestos is a fibrous magnesium, aluminum silicate formerly used for insulation and fire resistance. Its extensive uses are now hampered by reports of toxicity. All asbestos occurrences in Manitoba are in fractured, serpentinized ultramafic rocks. The Pipe Lake Mine, near Thompson, is the source of most of the asbestos samples recovered in the province. The rapidly falling demand for asbestos fibre makes this a low research priority item.

BARITE

In 1984, Canadian production of barite was valued at $7 million. Two major producers, one in B.C. and the other in Ontario, supplied the bulk of their production to the oil and gas drilling industry where barite is used as a weighting agent in well drilling fluids. Also used in pharmaceuticals, paints, plastics, rubber friction (brake) materials, glass and ceramics, Canadian demand for barite exceeds supply. Imports are primarily from Ireland and Morocco.

In Manitoba, barite was reported to occur in galena-barite viens which cut the massive sulphides of the Ruttan Mine in Leaf Rapids, in small cavities within a limestone quarry south of Camperville, and in minor amounts associated with gold-bearing veins of the San Antonio mine near Bissett. None of these occurrences are commercially significant at prices of $190-200 per tonne (1986). Unless other occurrences are reported barite remains a moderately low priority commodity.

COAL (LIGNITE)

Lignite is plant material that has been compressed and gently heated to drive off the volatiles and raise the fixed carbon content. The variety of lignite coal found in Manitoba has a high volatile component. It is found as thin seams within the Tertiary Turtle Mountain Formation on the northern and western slopes of Turtle Mountain. Several small mines were in production in this area around the turn of the century and again between 1931 and 1943, providing heating fuel for

neighbouring homesteads. Thin coal seams, high ash content and bad roof conditions contributed to the short life span of these operations.

Many companies and individuals have re-evaluated the coal seams in an attempt to operate them commercially. None were deemed economical so far, yet new occurrences of lignite are reported every year. Further study is not a priority since much work has already been done. It is unlikely any major new occurrence will be uncovered as the extent of Tertiary strata in Manitoba is well documented.

FLUORITE

Fluorite, commercially known as fluorspar, is a major industrial mineral used in the manufacture of hydrofluoric acid and as a fluxing agent for the aluminum and steel industries. Minor occurrences of fluorite are known in the province. One occurrence is a mass of fine grained purple fluorite in a rock found near Happy Lake, Bissett area, and another is in the Kasmere Lake area of northwestern Manitoba. If other occurrences are found they should be investigated. However, current prices and consumption outlook do not make Manitoba fluorite a priority for the near future.

KYANITE

Kyanite is an alumino-silicate mineral which is used mainly in the production of synthetic and acid refractories. Kyanite is not produced in Canada. Though small in scope, the world industry is experiencing steady growth.

Manitoba's occurrences of kyanite are products of metamorphism, where clay-rich alteration zones beneath massive sulphide deposits have been raised to the correct pressure and temperature. Several occurrences have been reported in the Snow Lake area. Minor occurrences are also known in the Lynn Lake area, on Karsakuwigamak Lake, on Gorman Lake, on Knee Lake, east of Knife Lake on Cat Eye Bay, Oxford Lake (alteration zone) and the east shore of Lake Winnipeg east of Black Island (alteration zone).

The Anderson Mine in the Snow Lake area contains several lenses of kyanite-rich sericite schist as well as disseminated kyanite crystals in chloritic schist. Other sulphide mineral occurrences contain aggregates of chlorite-garnet-staurolite-kyanite with some gahnite and biotite. The mineralogy of these zones is chemically controlled and can vary dramatically over a short distance, with variations in the Mg:Fe:Al ratio. Little is known of the extent and concentration of this potentially valuable by-product of the zinc-copper mines. More exploration may yield promising results.

IRON OXIDE

Iron oxide is used as a colouring agent in paint and a source of iron and steel production. There are several occurrences of iron oxide in Manitoba but none have a sufficiently large volume or are accessible enough to be exploited. These deposits include the Black Island hematite, and the iron formations at Shatford Lake, Neepawa, Pipestone Lake and Wallace Lake.

The deposit at Black Island is composed of pisolites of steely hematite in a carbonate matrix. The matrix appears to be later than the pisolites as it is molded around the spheres. The deposit is a slightly altered, ferruginous weathered zone developed on a pyritic body.

The deposit at Neepawa was found while drilling a large magnetic anomaly. It is a fine grained oxide iron formation that would be of little economic interest even at surface. At a depth of 762 metres it is of no economic interest.

The remaining iron formations are at the surface but are too poor in iron to be economic. Abundant iron-bearing matte exists as a by-product of the Thompson and Flin Flon smelting operations. At Thompson this material is used as grit for sand blasting and rock sawing. The grit (Norgrit) is close to silicon carbide in hardness and much cheaper. It has several other desirable properties for rock sawing, such as not being self-cementing, that make it an economically attractive product.

MERCURY

Mercury is critical to the production of many manufactured products including batteries, wiring and switching devices, lamps, chlorine and caustic soda, and paint. It is a product of recent volcanism and hot spring activity. The sulphide, cinnabar, is the most important mineral source of mercury.

Deposits of mercury are not known in Manitoba but most massive sulphide bodies contain it in minor amounts.

There have been no systematic studies of the mercury levels in the Flin Flon and Snow Lake orebodies. Further investigation may be warranted.

MAGNESITE

Magnesite is the best known mineral in which magnesium is found. Magnesium's valuable qualities include light weight, high strength and stiffness, and excellent heat dissipation. The major use of magnesium metal is as an alloying agent to aluminum. The mineral, magnesite, is also used in refractories of the iron and steel industry. At present the only producer of primary magnesium in Canada is located in Ontario.

Magnesite occurs in two environments: in ultramafic rocks, particularly serpentinites, and in certain dolomitic marbles. However, magnesite has not been found through mineralogical work on the Pipe Lake Mine serpentinite in Manitoba. Ultramafic rock at Loonfoot Island on Island Lake has a talc-magnesite-hematite phase but the location is too remote for viable development. Ultramafic bodies contain carbonate zones which in turn may contain dolomite or magnesite. More geological work is needed to determine the chemistry of carbonate zones in areas such as Island Lake and Iskwasum Lake to see if they contain magnesite.

MANGANESE

The iron and steel industry consume about 95% of the total manganese production in the world. A strategic commodity, manganese has no substitute and is essential in the production of nearly all types of steel. There is no domestic production and Canada currently imports manganese metal as an important additive in specialty steels and aluminum alloys.

All Manitoba deposits of manganese occur at or near the outcrop of the Odanah Member of the Cretaceous Riding Mountain Formation. Samples of reported manganese occurrences in the Swan River and Riding Mountain areas were collected in 1985 and are presently being analyzed for manganese and iron content. However, all of the deposits reported and sampled are too small and low in grade to be considered as ores of manganese.

MARL

Marl is a sediment composed of a mixture of clay minerals and calcite. It is the calcium carbonate which has applications in the fertilizer industry. For example, it can serve as an acid buffer to coat fertilizer and ease its spreading.

Samples of marl from north of Riverton were collected and tested in 1960 as a fertilizer coating agent. The material had excellent buffering capacity but retention of the fertilizer chemicals was too low to make the product viable. No further work has been done at this location. However, it is felt that a mixture of peat and marl, or bentonite and marl, might be more effective as a fertilizer carrier and should be investigated further.

PHOSPHATE

Apatite is mined extensively as a major component of fertilizer. Manitoba has three types of phosphate occurrences, all of which are small and currently subeconomic. These include sedimentary phosphate-rock, apatite-bearing metasediments and pegmatitic phosphates.

The sedimentary phosphate-rock deposits are of marine origin and occur as either highly fossiliferous beds or as concentrated phosphate nodules. A measured phosphate unit occurs in the Cretaceous shales of the Wilson River area. The thin and widespread phosphatic layers are derived mostly from fossil fish bones. A four centimetre thick layer has an 18% phosphate content. A second occurrence is in the upper portion of the Ordovician Winnipeg Formation. Two recorded analyses give a phosphate content of 0.09% and 4.8%.

The second type of deposit occurs as disseminated apatite and veins in the highly metamorphosed dolomite of the Nickel Belt. The quantity and phosphate content of this type of deposit is not known. Carbonatites are very similar in mineralogy to this type of deposit. The department has been actively seeking aeromagnetic signatures which are characteristic of carbonatites. To date none have been found. Further investigation is required to establish the extent of the resource.

Phosphates also occur within the pegmatites of the Bernic Lake area and are produced as a by-product of the mining of spodumene and tantalite. In the Tanco mine the most abundant phosphate minerals are apatite, amblygonite-montebrasite and lithiophilite.

CONCLUSION

The preceding commodity summary briefly outlines the amount of study and development of industrial minerals in Manitoba. The geological research requirements range from a high priority for such minerals as kyanite, garnet and expanded aggregates, to a lower priority for high-calcium limestone and dolomite for which recent reports exist.

Although additional exploration work is needed to confirm the extent of reserves, commodities such as chromite, glauconite and dimension stone present excellent resource development potential.

Existing mining operations such as cement, gypsum and aggregate resources have provided stable employment and revenue sources to the people of Manitoba. Additional research in bentonite, dolomite, peat, tantalum, and spodumene occurrences and demand may reveal expansion potential of the current producers.